

Earthquakes and Seismic Waves

Key Concepts

- How does the energy of an earthquake travel through Earth?
- What are the scales used to measure the strength of an earthquake?
- How do scientists locate the epicenter of an earthquake?

An earthquake is the shaking and trembling that results from the movement of rock below Earth's surface. The point below Earth's surface where rock under is under stress and breaks to cause an earthquake is the **focus**. The point on the surface directly above the focus is called the **epicenter**. During an earthquake, vibrations called **seismic waves** move out from the focus in all directions. **Seismic waves carry the energy of an earthquake away from the focus, through Earth's interior, and across the surface.**

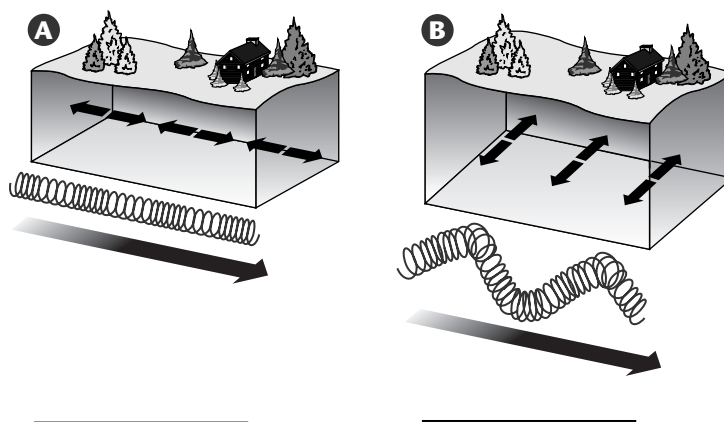
There are three categories of seismic waves: primary (P) waves, secondary (S) waves, and surface waves. An earthquake sends out two types of waves from its focus: primary waves and secondary waves. When these waves reach Earth's surface at the epicenter, they become surface waves. The first waves to arrive are primary waves, or P waves. **Primary waves are seismic waves that compress and expand the ground like an accordion.** After P waves come S waves, or secondary waves. **Secondary waves are seismic waves that vibrate from side to side as well as up and down.** They shake the ground back and forth. Unlike P waves, which travel through both solids and liquids, S waves cannot move through liquids. When P waves and S waves reach the surface, some of them become **surface waves**. Surface waves move more slowly than P waves and S waves, but can produce more powerful ground movements.

Three commonly used methods of measuring earthquakes are the Mercalli scale, the Richter scale, and the moment magnitude scale. The **Mercalli scale** was developed to rate earthquakes according to the level of damage at a specific place. An earthquake's **magnitude** is a number that geologists assign to an earthquake based on the earthquake's strength. Geologists determine magnitude by measuring the seismic waves and fault movement that occur during an earthquake. The **Richter scale** is a rating of an earthquake's magnitude based on the size of the earthquake's seismic waves. The seismic waves are measured by a seismograph. A **seismograph** is an instrument that records and measures seismic waves. Geologists today often use the **moment magnitude scale**, a rating system that estimates the total energy released by an earthquake. An earthquake's magnitude tells geologists how much energy was released by the earthquake. The effects of an earthquake increase with increasing magnitude.

Geologists use seismic waves to locate an earthquake's epicenter. When an earthquake hits, primary waves arrive at a seismograph first. Secondary waves arrive after the primary waves. The greater difference between the arrival times of the P waves and S waves, the farther away the epicenter is. This time difference tells scientists how far the epicenter is from the seismograph. Scientists then draw at least three circles using data from seismomographs all over the world. The center of each circle is a particular seismograph's location. The radius of each circle is the distance from the seismograph to the epicenter. The single point where the three circles intersect is the location of the earthquake's epicenter.

Earthquakes and Seismic Waves *(continued)*

4. Is the following sentence **true** or **false**? Seismic waves carry the energy of an earthquake away from the focus in all directions. _____.
5. Circle the letter of **each term** that is a category of seismic wave.
- a. primary wave
 - b. secondary wave
 - c. surface wave
 - d. magnitude wave
6. Label each drawing as *primary* or *secondary* waves.



7. Is the following sentence **true** or **false**? Surface waves move more quickly than P waves and S waves. _____

Type of Wave

Effect

____ 8. P wave

a. last to arrive

____ 9. S wave

b. compress and expand the ground

____ 10. Surface wave

c. shake the ground back and forth

11. A device that records the ground movements caused by seismic waves is a(n) _____.

Measuring Earthquakes

*12. List the three scales that are used for measuring earthquakes.

- a. _____
- b. _____
- c. _____

*13. Write a definition of each earthquake scale.

- a. _____

- b. _____

- c. _____

Locating the Epicenter

14. Is the following sentence **true** or **false**? The closer an earthquake, the greater the time between the arrival of P waves and the arrival of S waves.

*15. Geologists use circles to find the epicenter of an earthquake.

- a. What does the center of each circle represent? _____

- b. What does the radius of each circle represent?

Earthquakes and Seismic Waves

Understanding Main Ideas

Answer the following questions in the spaces provided.

1. What are seismic waves?

2. In what order do the three types of seismic waves arrive at a seismograph?

3. Which type of seismic wave produces the most powerful ground movements?

*4. Describe the moment magnitude scale, and explain why it is useful in measuring earthquakes. _____

*5. How do geologists locate the epicenter of an earthquake? _____

Building Vocabulary

Match each term with its definition by writing the letter of the correct definition in the right column on the line beside the term in the left column.

_____ 6. focus

_____ 7. epicenter

_____ 8. surface waves

_____ 9. seismograph

_____ 10. magnitude

a. records ground movements caused by seismic waves as they move through the Earth

b. slowest seismic waves that produce the most severe ground movements

c. the point beneath Earth's surface at which rock under stress breaks and triggers an earthquake

d. a measurement of earthquake strength

e. the point on the surface directly above the point at which an earthquake occurs

Comparing the Richter and Moment Magnitude Scales

The Richter scale rates earthquakes based on the size of their seismic waves, as measured by seismographs. The moment magnitude scale rates earthquakes based on the total amount of energy they release. To determine the moment magnitude rating, seismologists measure the surface area of the ruptured fault and how far the land moved along the fault. An earthquake's Richter rating and moment magnitude rating are not always the same. The table below shows the ratings on both scales for some famous earthquakes.

Date	Location	Magnitude	
		Richter scale	Moment magnitude scale
1811–1812	New Madrid, midwestern US	8.7	8.1
1906	San Francisco, California	8.3	7.7
1960	Arauco, Chile	8.3	9.5
1964	Anchorage, Alaska	8.4	9.2
1971	San Fernando, California	6.4	6.7
1985	Mexico City, Mexico	8.1	8.1
1989	San Francisco, California	7.1	7.2
1994	Northridge, California	6.4	6.7
1995	Kobe, Japan	6.8	6.9

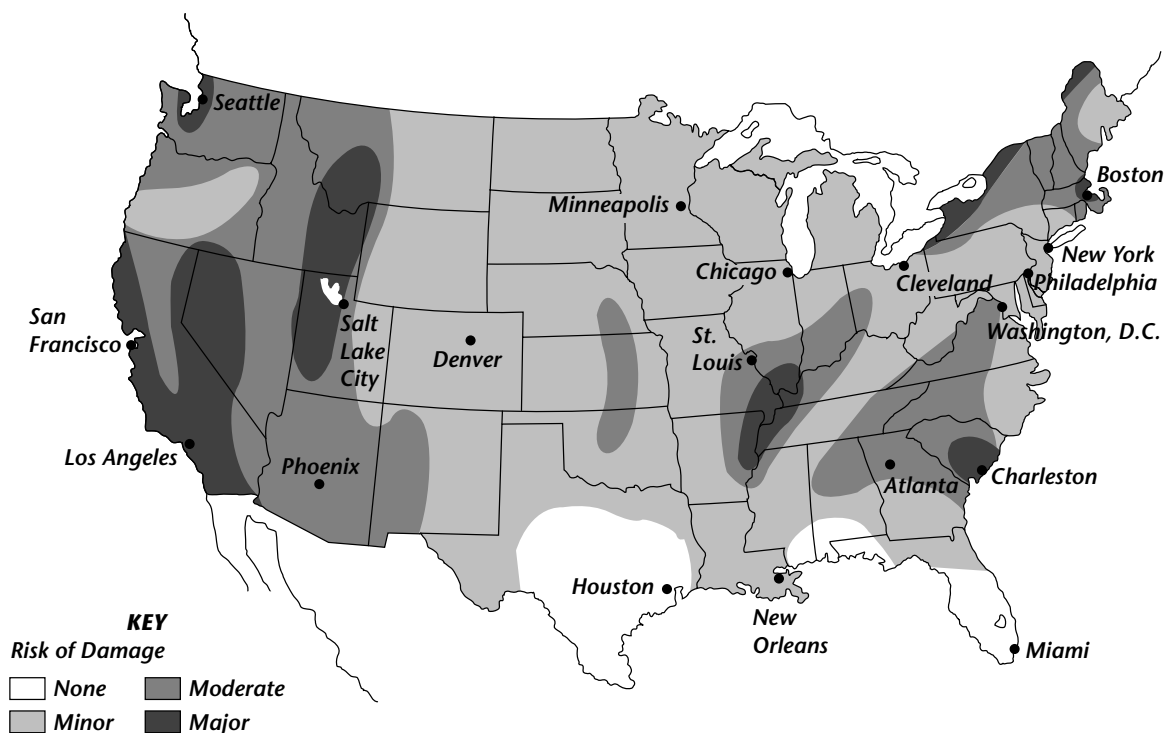
Answer the following questions on a separate sheet of paper.

1. Which earthquake was strongest according to the Richter scale? Which was strongest according to the moment magnitude scale?
2. Which earthquakes had the same or close to the same ratings on both scales?
3. Which earthquakes were rated more than 0.5 points stronger on the moment magnitude scale than they were rated on the Richter scale?
4. Which earthquakes were rated more than 0.5 points stronger on the Richter scale than they were rated on the moment magnitude scale?

Monitoring Earthquakes

Understanding Main Ideas

Answer the following questions.



1. What two factors help geologists determine earthquake magnitude?
2. Refer to the map above.
 - a. Name three cities that have a major risk of earthquake damage.
 - b. Name three cities that have a moderate risk of earthquake damage.
 - c. Name three cities that have a minor risk of earthquake damage.